

CLAIMS

What is claimed is:

1. A primary battery having a battery discharge voltage, said primary battery comprising:
at least one electrode comprising lithium;
one or more additional electrode;
said at least one electrode comprising lithium having a capacity greater than said one or more additional electrode; and
a nonaqueous electrolyte comprising a component having a decomposition voltage of between about 1 V and said battery discharge voltage.
2. The primary battery of claim 1 wherein said electrolyte comprises a lithium bis(chelato)borate.
3. The primary battery of claim 2 wherein said lithium bis(chelato)borate comprises lithium bis(oxalato)borate (LiBOB).
4. The primary battery of claim 3 wherein said LiBOB is said component having a decomposition voltage of between about 1 V and said battery discharge voltage.
5. The primary battery of claim 3 wherein said battery comprises carbon.
6. The primary battery of claim 5 wherein said carbon is a constituent of said additional electrode.
7. The primary battery of claim 3 wherein said additional electrode comprises fluorinated carbon.

8. The primary battery of claim 1 wherein said component comprises two or more components having a decomposition voltage of between about 1 V and said battery discharge voltage.
9. The primary battery of claim 1 wherein said component is selected from the group consisting of: vinylene carbonate (VC), vinyl ethylene carbonate (VEC), and mixtures thereof.
10. The primary battery of claim 1 wherein said component is selected from the group consisting of: lithium cyclopentadienide, lithium tetramethylcyclopentadienide, and mixtures thereof.
11. The primary battery of claim 1 wherein said component comprises vinyl sulfolane.
12. The primary battery of claim 1 wherein said component comprises carbon disulfide (CS₂).
13. The primary battery of claim 1 wherein said decomposition voltage is between about 1 V and about 3.5 V.
14. The primary battery of claim 13 wherein said decomposition voltage is between about 1 V and about 3 V.
15. The primary battery of claim 13 wherein said decomposition voltage is between about 1 V and about 2 V.
16. The primary battery of claim 13 wherein said decomposition voltage is between about 1.5 V and about 3 V.
17. The primary battery of claim 13 wherein said decomposition voltage is between about 1.5 V and about 2 V.

18. The primary battery of claim 1 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), dimethylsulfoxide (DMSO), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).

19. The primary battery of claim 1 wherein said electrolyte comprises a polymer electrolyte.

20. The primary battery of claim 1 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 10% greater than said theoretical capacity.

21. The primary battery of claim 1 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 20% greater than said theoretical capacity.

22. The primary battery of claim 1 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 30% greater than said theoretical capacity.

23. The primary battery of claim 1 wherein said additional electrode comprises carbon.

24. The primary battery of claim 23 wherein said carbon is fluorinated.

25. The primary battery of claim 24 wherein said additional electrode further comprises silver vanadium oxide.

26. The primary battery of claim 1 wherein said additional electrode further comprises silver vanadium oxide.

27. The primary battery of claim 1 wherein said lithium electrode comprises a material selected from the group consisting of: pure lithium metal, an alloy of lithium, mixed metals

containing lithium, lithium silicon, lithium silicon oxide, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

28. A primary battery having a battery discharge voltage, said primary battery comprising:
at least one anode having an anode capacity;
at least one cathode having a theoretical cathode capacity less than said anode capacity;
a nonaqueous electrolyte activating said at least one anode and said at least one cathode;
wherein
said primary battery has a usable capacity greater than said theoretical cathode capacity.

29. The primary battery of claim 28 wherein said electrolyte comprises a component having a decomposition voltage of between about 1 V and said battery discharge voltage.

30. The primary battery of claim 29 wherein said electrolyte comprises a lithium bis(chelato)borate.

31. The primary battery of claim 30 wherein said lithium bis(chelato)borate comprises lithium bis(oxalato)borate (LiBOB).

32. The primary battery of claim 31 wherein said LiBOB has a decomposition voltage of between about 1 V and said battery discharge voltage.

33. The primary battery of claim 29 wherein said component comprises two or more components selected from the group consisting of: lithium bis(chelato)borates, vinylene carbonate (VC), vinyl ethylene carbonate (VEC), lithium cyclopentadienide, lithium tetramethylcyclopentadienide, vinyl sulfolane, and CS₂.

34. The primary battery of claim 29 wherein said component is selected from the group consisting of: vinylene carbonate (VC), vinyl ethylene carbonate (VEC), and mixtures thereof.

35. The primary battery of claim 29 wherein said component is selected from the group consisting of: lithium cyclopentadienide, lithium tetramethylcyclopentadienide, and mixtures thereof.

36. The primary battery of claim 29 wherein said component comprises vinyl sulfolane.

37. The primary battery of claim 29 wherein said component comprises carbon disulfide (CS₂).

38. The primary battery of claim 29 wherein said decomposition voltage is between about 1 V and about 3.5 V.

39. The primary battery of claim 29 wherein said decomposition voltage is between about 1 V and about 3 V.

40. The primary battery of claim 29 wherein said decomposition voltage is between about 1 V and about 2 V.

41. The primary battery of claim 29 wherein said decomposition voltage is between about 1.5 V and about 3 V.

42. The primary battery of claim 29 wherein said decomposition voltage is between about 1.5 V and about 2 V.

43. The primary battery of claim 29 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), dimethylsulfoxide (DMSO), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).

44. The primary battery of claim 28 wherein said cathode comprises fluorinated carbon.

- 45.** The primary battery of claim 28 wherein said anode contains lithium.
- 46.** The primary battery of claim 28 wherein said electrolyte comprises a polymer electrolyte.
- 47.** The primary battery of claim 28 wherein said primary battery capacity is at least 10% greater than said theoretical cathode capacity.
- 48.** The primary battery of claim 28 wherein said primary battery capacity is at least 20% greater than said theoretical cathode capacity.
- 49.** The primary battery of claim 28 wherein said primary battery capacity is at least 30% greater than said theoretical cathode capacity.
- 50.** The primary battery of claim 28 wherein said cathode comprises carbon.
- 51.** The primary battery of claim 50 wherein said carbon is fluorinated.
- 52.** The primary battery of claim 51 wherein said cathode further comprises silver vanadium oxide.
- 53.** The primary battery of claim 28 wherein said cathode further comprises silver vanadium oxide.
- 54.** The primary battery of claim 28 wherein said anode comprises a material selected from the group consisting of: pure lithium metal, an alloy of lithium, mixed metals containing lithium, lithium silicon, lithium silicon oxide, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

- 55.** A medical device comprising at least one positive limited primary battery having a battery discharge voltage, said primary battery comprising:
at least one electrode comprising lithium;
one or more additional electrode;
said electrode comprising lithium having a capacity greater than said one or more additional electrode; and
a nonaqueous electrolyte comprising a component having a decomposition voltage of between about 1 V and said battery discharge voltage.
- 56.** The medical device of claim 55 wherein said component comprises a lithium bis(chelato)borate.
- 57.** The medical device of claim 56 wherein said lithium bis(chelato)borate comprises lithium bis(oxalato)borate (LiBOB).
- 58.** The medical device of claim 57 wherein said LiBOB is said component having a decomposition voltage of between about 1 V and said battery discharge voltage.
- 59.** The medical device of claim 56 wherein said additional electrode comprises fluorinated carbon.
- 60.** The medical device of claim 55 wherein said component comprises two or more components selected from the group consisting of: lithium bis(chelato)borates, vinylene carbonate (VC), vinyl ethylene carbonate (VEC), lithium cyclopentadienide, lithium tetramethylcyclopentadienide, vinyl sulfolane, and CS₂.
- 61.** The medical device of claim 55 wherein said component is selected from the group consisting of: vinylene carbonate (VC) and vinyl ethylene carbonate (VEC).
- 62.** The medical device of claim 55 wherein said component is selected from the group consisting of: lithium cyclopentadienide and lithium tetramethylcyclopentadienide.

- 63.** The medical device of claim 55 wherein said component comprises sulfolane.
- 64.** The medical device of claim 55 wherein said component comprises the additive carbon disulfide (CS₂).
- 65.** The medical device of claim 55 wherein said decomposition voltage is between about 1 V and about 3.5 V.
- 66.** The medical device of claim 55 wherein said decomposition voltage is between about 1 V and about 3 V.
- 67.** The medical device of claim 55 wherein said decomposition voltage is between about 1 V and about 2 V.
- 68.** The medical device of claim 55 wherein said decomposition voltage is between about 1.5 V and about 3 V.
- 69.** The medical device of claim 55 wherein said decomposition voltage is between about 1.5 V and about 2 V.
- 70.** The medical device of claim 55 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), dimethylsulfoxide (DMSO), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).
- 71.** The medical device of claim 55 wherein said electrolyte comprises a polymer electrolyte.
- 72.** The medical device of claim 55 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 10% greater than said theoretical capacity.

73. The medical device of claim 55 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 20% greater than said theoretical capacity..

74. The medical device of claim 55 wherein said primary battery has a theoretical capacity and an actual capacity and wherein said actual capacity is at least 30% greater than said theoretical capacity..

75. The medical device of claim 55 wherein said additional electrode comprises carbon.

76. The medical device of claim 75 wherein said carbon is fluorinated.

77. The medical device of claim 76 wherein said additional electrode further comprises silver vanadium oxide.

78. The medical device of claim 55 wherein said anode comprises a material selected from the group consisting of: pure lithium metal, an alloy of lithium, mixed metals containing lithium, lithium silicon, lithium silicon oxide, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

79. The medical device of 55 wherein said medical device is implantable.

80. A method for making a battery comprising:

providing at least one electrode comprising lithium;

one or more additional electrodes, wherein said electrode comprising lithium has a capacity greater than said one or more additional electrodes; and

activating said electrodes with a nonaqueous electrolyte comprising a component having a decomposition voltage of between about 1 V and said battery discharge voltage.

81. The method of claim 80 wherein said component comprises a lithium bis(chelato)borate.

82. The method of claim 80 wherein said component comprises lithium bis(oxalato)borate (LiBOB).
83. The method of claim 80 wherein said battery comprises carbon.
84. The method of claim 80 wherein said carbon is a constituent of said additional electrode.
85. The method of claim 80 wherein said additional electrode comprises carbon.
86. The method of claim 85 wherein said carbon is fluorinated.
87. The method of claim 86 wherein said additional electrode further comprises silver vanadium oxide.
88. The method of claim 80 wherein said additional electrode further comprises silver vanadium oxide.
89. The method of claim 80 wherein said component comprises two or more components selected from the group consisting of: lithium bis(chelato)borates, vinylene carbonate (VC), vinyl ethylene carbonate (VEC), lithium cyclopentadienide, lithium tetramethylcyclopentadienide, vinyl sulfolane, and CS₂.
90. The method of claim 80 wherein said component is selected from the group consisting of: vinylene carbonate (VC), vinyl ethylene carbonate (VEC), and mixtures thereof.
91. The method of claim 80 wherein said component is selected from the group consisting of: lithium cyclopentadienide, lithium tetramethylcyclopentadienide, and mixtures thereof.
92. The method of claim 80 wherein said component comprises vinyl sulfolane.
93. The method of claim 80 wherein said component comprises carbon disulfide (CS₂).

94. The method of claim 80 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), dimethylsulfoxide (DMSO), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).

95. The method of claim 80 wherein said electrolyte comprises a polymer electrolyte.

96. The method of claim 80 wherein said lithium electrode comprises a material selected from the group consisting of: pure lithium metal, an alloy of lithium, mixed metals containing lithium, lithium silicon, lithium silicon oxide, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

97. A method for determining end of life of a primary battery comprising:

providing a primary battery having a battery discharge voltage and a battery discharge voltage profile, said primary battery comprising:

at least one electrode comprising lithium;

one or more additional electrodes;

said electrode comprising lithium having a capacity greater than said one or more additional electrodes;

a nonaqueous electrolyte comprising a first component having a decomposition voltage of between about 1 V and said battery discharge voltage; and

monitoring said battery discharge voltage profile for a plateau corresponding to said decomposition voltage.

98. The method of claim 97 wherein said component comprises a lithium bis(chelato)borate.

99. The method of claim 98 wherein said lithium bis(chelato)borate comprises lithium bis(oxalato)borate (LiBOB).

100. The method of claim 98 wherein said additional electrode comprises fluorinated carbon.

- 101.** The method of claim 97 wherein said decomposition voltage is between about 1 V and about 3.5 V.
- 102.** The method of claim 97 wherein said decomposition voltage is between about 1 V and about 3 V.
- 103.** The method of claim 97 wherein said decomposition voltage is between about 1 V and about 2 V.
- 104.** The method of claim 97 wherein said decomposition voltage is between about 1.5 V and about 3 V.
- 105.** The method of claim 97 wherein said decomposition voltage is between about 1.5 V and about 2 V.
- 106.** The method of claim 97 wherein said electrolyte further comprises a second component having a decomposition voltage less than that of said first component.
- 107.** The method of claim 106 wherein said first and second components are selected from the group consisting of: lithium bis(chelato)borates, vinylene carbonate (VC), vinyl ethylene carbonate (VEC), lithium cyclopentadienide, lithium tetramethylcyclopentadienide, vinyl sulfolane, and CS₂.
- 108.** The method of claim 97 wherein said battery comprises carbon.
- 109.** The method of claim 108 wherein said carbon is a constituent of said additional electrode.
- 110.** The method of claim 108 wherein said carbon is fluorinated.
- 111.** The method of claim 110 wherein said additional electrode further comprises silver vanadium oxide.

112. The method of claim 97 wherein said additional electrode further comprises silver vanadium oxide.

113. The method of claim 97 wherein said lithium electrode comprises a material selected from the group consisting of: pure lithium metal, an alloy of lithium, mixed metals containing lithium, lithium silicon, lithium silicon oxide, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

114. A primary battery comprising:
at least one electrode comprising lithium,
one or more additional electrode, and
an electrolyte comprising lithium bis(oxalato)borate (LiBOB) or at least one byproduct of LiBOB.

115. The primary battery of claim 114 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).

116. The primary battery of claim 114 wherein said electrolyte further comprises dimethylsulfoxide (DMSO).

117. The primary battery of claim 114 wherein said electrolyte comprises a polymer electrolyte.

118. The primary battery of claim 114 wherein said lithium electrode comprises a material selected from the group consisting of: pure lithium metal, lithium silicon, lithium silicon oxide, other alloys of lithium, mixed metals containing lithium, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

119. The primary battery of claim 114 wherein said additional electrode comprises carbon.

120. The primary battery of claim 119 wherein said carbon is fluorinated.

121. The primary battery of claim 119 wherein said additional electrode further comprises silver vanadium oxide.

122. A medical device comprising at least one positive limited primary battery comprising:

at least one electrode comprising lithium;

one or more additional electrodes; and

an electrolyte comprising lithium bis(oxalato)borate (LiBOB).

123. The medical device of claim 122 wherein said electrolyte further comprises one or more solvents selected from the group consisting of: propylene carbonate (PC), 1,2-dimethoxyethane (DME), diethyl carbonate (DEC), propyl acetate (PA), gamma-butyrolactone (GBL), tetrahydrofuran (THF), ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethylcarbonate (DMC).

124. The medical device of claim 122 wherein said electrolyte further comprises dimethylsulfoxide (DMSO).

125. The medical device of claim 122 wherein said electrolyte comprises a polymer electrolyte.

126. The medical device of claim 122 wherein said lithium electrode comprises an a material selected from the group consisting of: pure lithium metal, lithium silicon, lithium silicon oxide, other alloys of lithium, mixed metals containing lithium, lithium graphite intercalation compound (LiGIC), and other lithiated carbon.

127. The medical device of claim 122 wherein said additional electrode comprises carbon.

128. The medical device of claim 122 wherein said additional electrode comprises fluorinated carbon.

129. The medical device of claim 128 wherein said additional electrode further comprises silver vanadium oxide.

130. The medical device of claim 122 wherein said additional electrode comprises silver vanadium oxide.

131. The medical device of 122 wherein said medical device is implantable.

132. A method for making a primary battery comprising:
providing at least one electrode comprising lithium,
providing one or more additional electrodes, and
activating said electrodes with an electrolyte comprising lithium bis(oxalato)borate (LiBOB).

133. The method of claim 132 wherein said electrolyte further contains at least one additional salt.

134. The method of claim 132 wherein said electrolyte further comprises dimethylsulfoxide (DMSO).

135. The method of claim 132 wherein said additional electrode comprises fluorinated carbon.

136. A method for improving storage capability of a primary battery having a cathode, a lithium-containing anode, and a nonaqueous electrolyte, comprising:
adding lithium bis(oxalato)borate (LiBOB) to the electrolyte.

137. The method of claim 136 wherein said cathode comprises fluorinated carbon.

138. A method for increasing the voltage of a primary battery having a CF_x -containing cathode and a lithium-containing anode, comprising:

activating the cathode and anode with an electrolyte comprising lithium bis(oxalato)borate (LiBOB) and dimethylsulfoxide (DMSO).